THE United States Signal Service has recently constructed a telegraph line to the summit of Pike's Peak, in Colorado, which is said to be the highest point reached by any line in the United States, or perhaps in the world. The height is said to exceed 11,000 ft. Regular reports as to the weather are to be sent to Washington three times daily.

THE additions to the Zoological Society's Gardens during the past week include an American Cross Fox (*Canis fulvus*), a Golden Eagle (*Aquila Chrysaëtus*), and a Virginian Eagle Owl (*Bubo virginianus*), from North America, presented by Capt. D. Herd; a Mexican Deer (*Cervus mexicanus*), from Porto Rico, presented by Mr. W. Isaacson; two Sand Badgers (*Meles ankuma*), from Japan, presented by Lieut. Hon. A. C. Littleton; a Black-eared Marmoset, (*Hepale penicillata*), from Brazil, presented by Mr. C. Hawkshaw; a Spotted Hyæna (*Hyæna erocuta*), and two Bronze-winged Pigeons (*Phaps chalcoptera*), born in the Gardens; two Rheas (*Rhea americana*), from S. America, deposited; two Chilian Tinamous (*Rhynchotus perdicarius*), three Banded Tinamous (*Crypturus noctivagus*), and two Obsolete Tinamous (*C. obsoletus*), from S. America, received in exchange.

ORIGINAL RESEARCH AS A MEANS OF EDUCATION[*]

II.

IT is the greatest possible mistake to suppose—as, unfortunately, many yet do—that a scientific education unfits a man for the pursuits of ordinary professional or commercial life. I believe that no one can be unfitted for business life or occupations by the study of phenomena, all of which are based upon law, the knowledge of which can only be obtained by the exercise of exact habits of thought, and patient and laborious effort. I dare say many who have had a scientific education make bad men of business, but so do many who have not had such an education; it is not the scientific education which has spoilt them. Even more directly does the value of scientific education bear upon professional and manufacturing life. The medical man's success depends mainly upon the exercise of faculties which are pre-eminently called forth, and strengthened in original scientific investigations. The manufacturer who aspires to something more than following the rule-of-thumb work of his predecessors, requires exactly these habits of mind which are developed by original research. If the brewer, the calico-printer, the dyer, the alkali-maker, the metallurgist wish to make any advance of their own in their respective trades, they cannot do so without the exercise of powers which can only be gained by the prosecution of original inquiry. Doubtless many—nay, even most—of the great discoveries and improvements in the arts and manufactures may have been made by men who have been self-taught. But these men have acquired for themselves, by slow and difficult steps, the same habits of exact observation, patient and laborious devotion, and manipulative or constructive skill which the modern student of science may, at any rate to a very considerable extent, gain in his college course. So valuable is this kind of education found to be, that in Germany, where it is most practised, the chemical manufacturers now refuse to take young men into their works unless they have not merely had a scientific education, but also have prosecuted original investigation.

If, then, education in its widest sense has for its objects, as I presume will be generally allowed, the training of the mind and faculties in such a way as most fully to qualify the possessor to discharge with benefit to mankind his duties in after-life, surely plans for the encouragement of original scientific research should form no inconsiderable portion of the work of every institution professing to deal with the higher education of the country. And yet when we come to look at the provision made for encouraging original research, either at our older or at most of the more modern seats of learning, we are astonished to find that this essential provision is almost altogether ignored. At Oxford and Cambridge thousands of pounds are each year lavished upon the encouragement of classical and mathematical attainments, whilst the claims of original research can scarcely be said to be recognised. Hence these highly endowed universities, whilst they are justly celebrated for their critical faculties, have ceased to represent, in any one direction, the productive power of the country.

Original research, the true life-breath of civilisation, does not in England, as is the case in Germany, look to the universities as the nurseries where its young shoots shall be tended and cherished, for there, at present, its value is scarcely recognised. Indeed, Sir William Thompson has expressed his opinion that the system of examinations at the universities has a tendency to repress original inquiry, and exerts a very injurious effect in obstructing the progress of science. The time is, however, not far distant when this want of appreciation of the value of original research will be a thing of the past, and when the universities will vie with each other in encouraging this mainspring of progress, and in honouring more those whose lives are devoted to this high calling. Owing to the want of means of promoting original investigation in our great seats of learning, the scientific activity of the country has found vent through other channels. No want of encouragement can repress really great minds or powerful wills. Manchester can boast the names of many men who, in spite of want of university aid, have done much for science. Who, for instance, in the whole scientific annals of Oxford, can be placed on a footing of equality with Dalton or Joule? These men are, however, great in spite of our systematic negligence of the subjects, the mastery over which has made their names immortal.

If, in the face of so much that is discouraging in this want of recognition of science, England has still no reason to fear the comparison of her great men of science with those of other countries, we may feel sure that our position among the nations will be raised when the Government, our universities, and the country at large become alive to their duties as regards the encouragement of original scientific research, and when the number of able men who devote themselves to this pursuit shall thereby be largely increased. Much assistance in this direction may confidently be expected from the Royal Commission on Scientific Instruction and the Advancement of Science, of which his Grace our President is chairman, and which has lately published its third report on the progress of scientific education and research in the two old universities. In this report, the importance, from a national point of view, as well as an educational instrument of original research is fully recognised, whilst the means of enabling the universities to take their due share in the management of this branch of human activity is suggested. The evidence given before this Commission by Sir Benjamin Brodie, Prof. Frankland, Dr. Carpenter, and other competent authorities, is of the most decided and unanimous character, and the opinion thus strongly expressed must ere long produce its effect.

The importance of fostering scientific research in connection with higher education is, however, now well understood to the authorities of this college. Very considerable facilities for carrying out original work are given both to the teachers and to the pupils, whilst in the appointment of the professors special weight is always laid on their power of conducting scientific research. In my department, which has now been organised for many years, I make bold to say that we have not been behind any chemical laboratory in this kingdom in the original work we have produced. The physical laboratory, which has only recently been inaugurated, has already, under the care of its talented Director, whose original researches are valued wherever Science is appreciated, done valuable work, and the new department of practical physiology which has just been established will doubtless soon bear fruit of a similar character. In the biological sciences our teaching resources have hitherto been limited; but although this has necessarily prevented the prosecution of research by the students, the professors of this department have long been distinguished for original investigation in their special branches.

To assist in developing in the practical community the appreciation of scientific research, and owing to the liberality of Manchester men and to the wise advice of Prof. Frankland, who then occupied the chair which I have now the honour to hold, a scholarship for original chemical research—our Dalton Chemical Scholarship—was founded in 1853 as a testimonial, and a fitter one could not have been proposed, to our great townsman. The establishment in England of a scholarship for excellence in original research was, twenty years ago, a circumstance without a parallel, but in spite of the novelty of the experiment, time has fully proved the wisdom of the course which its originators adopted. We can already point to a fairly long list of men who have taken our Dalton Scholarship, who now hold high and responsible positions in scientific, manufacturing, and official life; and these men will all acknowledge the benefit conferred upon them by the training they received when competing for the scholarship, and whilst occupied for the first time in their lives in carrying out an investigation on some original subject.

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[*] Concluded from p. 539.

On the model of our Dalton Chemical Scholarship, an important physiological scholarship has lately been founded in this College by Mr. Robert Platt; the conditions of tenure involve the prosecution of an original investigation in physiology; and it is to be hoped and expected that this scholarship will do as much to stimulate the study of physiology amongst us as the Dalton has certainly done in the case of chemistry. The establishment of similar scholarships in the branches of physics and biology is much to be desired, and benefactions made for these special purposes will assuredly prove of the greatest value.

It is unnecessary for me to point out the direct applications which the knowledge and experience gained in the laboratory receive in the arts and manufactures dependent upon chemical science. These everyone can see for himself. The ordinary routine work of the alkali maker, the dyer, the brewer, the calico printer, calls immediately for chemical knowledge, and manufacturers who do not yet see the value of the training afforded by original experimental investigation, are ready enough to appreciate chemical knowledge if it can show them that their drugs are adulterated or their water impure.

Concerning the exact mode by which encouragement should be given in this country to original research, opinions may differ. One proposal has lately been made by the distinguished president of the British Association (Prof. A. W. Williamson), in his able address at Bradford, which it behoves all interested in the progress of the country carefully to consider. Without attempting to discuss the details of this or other schemes, it may be well to point out those general features of the subject upon which these proposals are based.

In the first place, then, we shall agree that the measures which have to be taken must be systematic, must apply to the country at large, and must include all classes. What we need is the development of the latent intellectual resources of the country as regards science, the means of sifting out from the great mass of the people those golden grains of genius which now too often are lost amongst the sands of mediocrity. This can only be fully accomplished by a system extending from the lowest primary schools up to the highest educational establishments in the land, and therefore almost necessitates the action of Government. But whilst believing that a national system is needed in order that the potential scientific energy of the country shall become active, I for one should most strongly object to the establishment of a complete system of State education. One of our greatest safeguards and sources of national strength has been and is the freedom from Government control which our educational, municipal, and local institutions have always enjoyed; and the evils of a uniform State system as existing in France (which is such that the Minister for Education remarked with pride, that at a given moment the classes in all the Lycees in France were engaged in reading the same chapter in Cæsar's Commentaries) need only be felt to be deplored.

Secondly, it is clear that in order to be able to select from amongst the people those whose mental and physical powers fit them for ultimately advancing science themselves, the rudiments of a scientific training must be much more widely diffused than is at present the case. This can only be slowly accomplished; the methods of teaching science are only beginning to be understood, and, unfortunately, in school teaching the introduction of a scientific subject has too often been looked upon more as an amusement than as a study requiring as much or more attention and exactitude than the older subjects, one which when properly taught acts to quite as great an extent as a mental discipline. Science teachers have yet to be trained, and a system of introducing elementary science as disciplinary teaching into primary and secondary schools has yet to be made general. At the same time new institutions have to be founded in which the higher branches of the various sciences are taught and original research encouraged, and into which youths of conspicuous merit must be drafted, whilst existing colleges and universities have to be modified to suit the requirements of the time. These institutions must contain laboratories, not only for teaching purposes, but suited for scientific research, and the professors must take in a certain number of advanced students to work on original investigation. This is indeed, as Sir Benjamin Brodie points out in his evidence before the commission, an educational function of the most important character; because here scientific education is carried out to its end, and if this is not done, you stop short of the most important part of all in scientific education, for the perfection of science as a means of education is seen only in scientific inquiry. The pupils thus trained eventually pursue science as their main business in life, and become in their time teachers and professors of their subject. Thus by degrees the profession of the investigating teacher will become recognised as one in which the ablest of our youths may obtain reward and recognition, as well as satisfaction and delight, and thus the scientific power of the country will be vastly increased.

Concerning the ennobling nature of original scientific inquiry it is needless for me to say much, for although I should be the last to contend that men of science are free from the foibles and weakness common to all mankind, I think it stands to reason that the habits of mind which an investigator must cherish, are such as must raise him above the petty struggles of ordinary existence, and must, for a time at least, lift him into an atmosphere free from the cloud and smoke which too often darken the usual current of men's lives. In order to give you an idea in what original research consists, and to point out to you the interests attaching to an inquiry, the practical applications of which seem as far distant as those of a newly-discovered planetoid, I will for a few moments draw your attention to a case of the kind with which I happen to be familiar. Amongst the sixty-three different elements of which the earth, so far as we know, is made up, there are many which have been found only in the most minute quantity. Indeed, in the list of elements suspended on the wall, you will notice that a large number out of the sixty-three are marked as rare. A few only of these substances are employed in the arts and manufactures, or are known to play any part in the economy of nature; the rest are rarities of interest at present only to the scientific chemist. It would, however, be presumptuous on our part were we to assume that the existence of these bodies is a matter of no moment, for we are constantly learning that substances hitherto supposed to be useless are of the most vital importance. Hence it is obviously our duty to get to know all we can about the properties of each, even the rarest, of these elementary bodies, and especially about their relation to, and mode of action on, the other elements. It is clear, too, that as long as our knowledge of the properties of any one of these elementary bodies is inaccurate, or if mistaken views regarding any one have arisen, our science must suffer in completeness. For just as an error made in the basement of a house throws the upper storeys wrong, so a mistake concerning the size and shape of the foundation blocks of our science may render the whole chemical superstructure faulty.

In 1830 the great Berzelius fully examined a new elementary body termed vanadium, the existence of which had been previously discovered by his countryman Sefström. Having most carefully ascertained the remarkable properties of this new substance and its compounds with the other elements, Berzelius gave to vanadium and its compounds a certain chemical position and place amongst the other elements. Thus to the compound of vanadium and oxygen containing the largest proportion of the latter element, and called vanadic acid, he assigned the formula V_2O_3, meaning thereby, in the atomic language of our great townsman Dalton, that two indivisible particles or atoms of the metal are combined with three indivisible particles or atoms of oxygen; and these views, enforced by experiments of the most unimpeachable character, were for years universally adopted by chemists.

In 1858 a fact was observed by the German chemist, Rammelsberg, with regard to the crystalline form of the best known mineral containing vanadium which exhibited Berzelius's conclusions in a new light. It had long been known that substances which have an analogous chemical composition are found to crystallise in an identical form. Thus the different alums containing alumina, oxide of iron, oxide of chromium, oxide of manganese, all crystallise in octahedra; and the oxides contained in these alums have all an analogous composition; that is, the relations between the number of atoms of metal and of oxygen in each case is identical. Now, Rammelsberg found that the crystalline form of a mineral contained vanadic acid, and lead was identical with another mineral containing phosphoric acid and lead. Hence we should expect to find that the oxide of vanadium, termed vanadic acid, and the oxide of phosphorus, called phosphoric acid, possess an analogous chemical constitution. Such, however, was found not to be the case. Phosphoric acid is well known, and, without doubt, consists of two atoms of phosphorus, united with five atoms of oxygen, whereas Berzelius only found three atoms of oxygen to two of the rare metal in vanadic acid. How is this discrepancy to be explained? We have here to do either with an exception to the otherwise general law of isomorphism, so that we may have identity of crystalline form, without any analogy in chemical composition, or Berzelius's experiments and conclusions respecting the constitution of this vanadic acid are incorrect. By experiments on the properties of vanadium and its compounds, made with much larger quantities than it fell to the lot of the Swedish chemist to work with, it was shown that something had been overlooked by him. It was proved that the substance which he supposed to be a metal was not a metal at all, but an oxide, and that vanadic acid really contains more oxygen than he believed it to contain. And what is remarkable is that this quantity of oxygen, which had been overlooked, is exactly the quantity which is needed in order to make the constitution of vanadic acid identical with that of phosphoric acid. We have to take out of each atom of Berzelius's metal one atom of oxygen in order to get the true vanadium, so that the real atomic weight of this element is less than that given to it by Berzelius by the atomic weight of oxygen, $67{\cdot}3 - 16 = 51{\cdot}3$. Thus the chemical constitutions of phosphoric and of vanadic acids are represented by the formulæ $P_2\,O_5$. $V_2\,O_5$. The law of isomorphism remains unassailed, and the goddess (Vanadis is a cognomen of the Scandinavian goddess Freia) who was found wandering as a waif and a stray amongst her companion elements, has been restored to her natural friends, and now forms a recognised member of a family group.

To sum up, my aim in the foregoing remarks has been to show that if freedom of inquiry, independence of thought, disinterested and steadfast labour, habits of exact and truthful observation, and of clear perception, are things to be desired as tending to the higher intellectual development of mankind, then original research ought to be encouraged as one of the most valuable means of education. And that on this ground alone, and independent of the enormous material benefits which such studies confer on the nation, it is the bounden duty not only of the Government, but of every educational establishment, and of every citizen of this country who has the progress of humanity at heart, to promote and stimulate the growth of original research amongst us.

HELVETIC SOCIETY OF NATURAL SCIENCES

THE fifty-sixth annual meeting of this society was held on the 18th, 19th, and 20th of August last, at Schaffhouse, under the presidency of Dr. Stierlin, and is described as having been a highly animated one. We shall note a few of the more important papers presented; for particulars of which we are indebted to the *Archives des Sciences*.

In the section of Physics and Chemistry, M. Soret described a method for studying ultra-violet spectra. It consists in placing a thin fluorescent lamina (sulphate of quinine, *e.g.* between two glass plates) before the eyepiece of a spectroscope, where the image is formed, and observing, with sufficient inclination of the eyepiece the image of the ultra-violet spectrum then developed on the lamina. Prof. Kopp read a paper on bresiline and its derivatives. The Deacon process of manufacturing chlorine was the subject of a paper by M. Hurter, which gave rise to lively discussion. Dr. Heim, who has been observing the sounds of cascades, find they all give the note C sharp, or F.

In Geology, Dr. Schalch had a paper on the volcanic rocks of Höhgau. These are in two groups, that of basalts, and that of phonolites. They form isolated cones surrounded with thick deposits of volcanic tufa, the nature and arrangement of which indicate that the eruptions happened at successive intervals about the end of the tertiary epoch. M. Favre showed a section of the Vaudois Alps made at Pleiades, near Vevey aux Ormonts; in which he distinguishes three zones, consisting of superior Jurassic and Neocomian, and different portions of Eocene, strata. Dr. Heim exhibited a new method of geological representation of a country; it consists in a series of sections, on the same scale, coloured and fixed vertically at equal distances on a geological map. He also made some observations on the zone of contact of crystalline rocks and sedimentary strata in Eastern Switzerland and the Bernese Alps. M. Lang announced the early publication, by the Alpine Club of a glacier-register, in which information will be given as to dimensions, form progress, &c., of glaciers. At the first general *séance* Prof. Heim gave a valuable *resumé* of the various theories of glacial motion. At the second, Prof. Desor presented a memoir on *morainic* landscapes, by which he denotes those indicating a former extension of glaciers. The most striking types are at the southern base of the Alps. There is discernible a zone consisting of a succession of verdant hillocks, sometimes aligned, sometimes separate; these are found to be composed of the *débris* of old formations bruised and triturated, and clearly indicating glacial action. A good example occurs at the base of Monte Campo di Fiori.

At the general opening *séance* Prof. Forel gave an account of his researches on the deep-water fauna in Lake Leman, of which he enumerates some thirty species. He had also studied the fauna of the lakes of Neuchatel, Zurich, and Constance. His conclusions are briefly these:—There are in the lakes three distinct fauna: (*a*) a littoral, extending to 15 or 20 metres depth; (*b*) a deep fauna, from 20 to 300 metres; and (*c*) a pelagic fauna. All the forms of the deep fauna have analogous or similar forms in the littoral fauna; but the converse does not hold, At the same level the deep fauna are the same. A few species found between 30 and 100 metres are not found at 300 metres. but all the types at 300 metres are found between 30 and 100 metres. There are local and seasonal differences. The deep fauna are best studied between 30 and 60 metres. In comparing different lakes the general characters of deep fauna are the same, but special characters vary.

In the section of zoology and botany, M. Bugnion described some sensitive organs found in the epidermis of Proteus and Axolotl. They are considerably developed in the former (1460 were counted in one specimen), and are disposed in linear groups of three or four along certain nerves of the head, and the lateral nerve to the end of the tail. They resemble the cyathiform organs discovered by M. Leydig in 1850, in the epidermis of fishes. Dr. Cartier gave a paper on the sensitive hairs of crocodiles.

In the medical department Prof. Karsten, of Vienna, made a communication on *necrobiosis* in which he pointed out that Bacteria, Vibriones, and micro-coccus, &c., are not to be regarded as organic species, properly so called; the phenomena of animal reproduction have never been observed in them. They are pathological products, which grow in the interior of vegetable or animal cells, but which do not penetrate these when once developed, as parasites.

In the department of Pure Mathematics the principal paper was by Prof. Schwarz on a new example of a continual function which does not admit of derivatives. This paper will be found *in extenso* in the *Archives*.

This is the third time in its history that the Helvetic Society has met at Schaffhouse, the former occasions having been in 1825 and 1847. The next annual session is to be held at Coire.

SCIENTIFIC SERIALS

Sitzungsberichte der Königl. Böhmischen Gesellschaft der Wissenschaften in Prag. Jan. 1871 to June 1872. (3 numbers).—Among the more valuable matter in these numbers may be noted some contributions to palæontological botany; more especially a paper by M. Feistmantel describing the various fruit-forms met with in Bohemian coal formations. (As published separately, the paper contains several excellent plates). The same author communicates also full accounts of the flora in coal-measures at the foot of the Riesengebirge, and at Merklin.—M. Dvorak describes some curious experiments on individual differences between the two eyes, and between different parts of the retina of the same eye. He shows that two non-simultaneous impressions, each affecting one eye, appear simultaneous, when the time-interval is of a certain length; this interval he measures with suitable apparatus.—In chemistry we have a note by Prof. Stolba, giving a new method of preparing borofluoride of potassium, and an account of the properties of this substance.—Dr. Weyr investigates mathematically the distance-action of electrical solenoids on material plane surfaces; and a note by M. Domalip furnishes experimental proof of certain laws deduced by M. Dub as to the dependence of magnetic moment on the dimensions of a magnetic bar.—There are also papers on the fauna of lakes in the Böhmerwald, on basaltic formations, and on several points in mineralogy and pure mathematics.

Bulletin de l'Académie Royale de Belgique, No. 8, 1873.—In this number is described a recording *meteorograph*, devised by M. Van Rysselberghe, and which seems to have some merit;